Abstract View

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A Three-Dimensional Simulation of the Hudson–Raritan Estuary. Part II: Comparison with Observation

Lie-Yauw Oey and George L. Mellor

Geophysical Fluid Dynamics Program, James Forrestal Campus Princeton University Princeton NJ 08542

Richard I. Hires

Department of Civil & Ocean Engineering, Stevens Institute of Technology, Hoboken, NJ 07030

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ABSTRACT

Results from a time-dependent, three-dimensional numerical simulation of the Hudson–Raritan estuary are compared with observations. The comparison includes: 1) instantaneous salinity contours across a transect in the estuary; 2) amplitudes and phase of tidal constituents at four tide gauge and five current meter stations, 3) mean currents at nine meter locations, and mean salinity in the Hudson River, 4) kinetic energy spectra; and 5) response to wind forcing of subtidal current at an observational station near the mouth of the estuary.

Observations confirm the model's prediction of existence of density advection instabilities induced by differential advection of the three-dimensional density field. These instabilities produce intense vertical mixing and should significantly modify dispersion processes in the estuary. Effects of neap–spring tides on vertical stratifications are also simulated by the model. Simulated M_2 phase at three tide gauge stations show improvement over the M_2 phases obtained from a two-dimensional, vertically integrated tidal model. The improvement is presumably due to bottom boundary layer resolution and, therefore, improved representation of bottom friction in the three-dimensional model. Simulated (instantaneous and mean) currents compare reasonably well with observations, except at narrow channel regions where the model's resolution is inadequate. Simulated “density-induced” mean currents are weaker than those observed, a discrepancy attributed to neglect of temperature variations in the model. Horizontal diffusion coefficients are null in this model. The burden of horizontal dispersion is generally handled well by the model's adequate resolution of small-scale advective processes, as suggested by the model's correct simulation of the k^{-3} transfer spectrum law at high wavenumber k. In narrow rivers that are modeled two-dimensionally (x, z), the estimate of the horizontal dispersion due to vertical variabilities in velocity and salinity appears to be correct; however, mixing by lateral variability is absent so that the saline intrusion

is somewhat underpredicted. At the mouth of the estuary, simulated subtidal current responses to wind forcing generally agree with observed responses. The response is partly barotropic, which is a result of balance between bottom friction, sea level setup from the adjacent continental shelf and wind stress, modified by local vertical velocity shears and baroclinic responses.